Modular DC-DC Converters for Fuel Cell Hybrid Power Supply in Heavy-Duty Vehicles

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This study explores the development and optimization of modular DC-DC power converters, specifically tailored for integration with fuel cell-based hybrid power systems in heavy-duty transportation applications. It focuses on various converter configurations, including interleaved boost converter [1] and the floating interleaved boost converters [2]. A key innovation in this research is the enhancement of the floating interleaved boost converter through the integration of coupled inductors, which optimizes the use of magnetic components, reduces the system size and improve thermal management [3].

Critical performance metrics such as efficiency, voltage gain, and fault tolerance are evaluated through simulations conducted in MATLAB and Simulink. Results reveal that interleaved boost converters substantially improve system efficiency and diminish voltage and current ripples. Floating converters, building upon the advantages of interleaved boost configurations, also manage extended voltage ranges and exhibit superior fault tolerance.

Additionally, this research introduces pioneering hybridization strategies using batteries, supercapacitors or Li-ion capacitors [4][5]. These strategies not only stabilize the power supply but also prolong the operational life of fuel cells by buffering intermittent loads and reducing hydrogen consumption [6]. These advances increase the robustness of power systems and contribute to the development of sustainable solutions for heavy-duty transport, with the potential to significantly reduce carbon emissions.

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